Precise Measurement of α_k for the 39.76-keV *E3* Transition in ^{103}Rh:
A Further Test of Internal Conversion Theory

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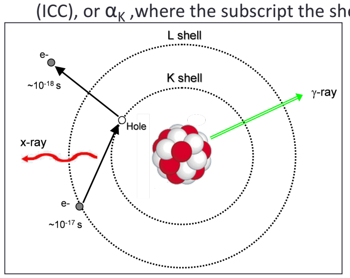
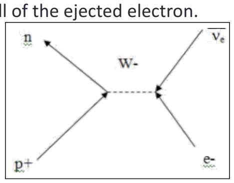
THEORY

- When a nucleus decays from an excited state to its ground state, it can emit the excess energy in the form of a gamma ray. Alternatively, if the wave function of an atomic electron overlaps the nucleus, that electron can be ejected in a process known as internal conversion.
- When an orbital electron is ejected, an electron from a higher energy shell jumps down to fill the vacancy and a characteristic x-ray is emitted in the process.
- The ratio of the probability for the nucleus to decay by internal conversion to γ-emission is called the Internal Conversion Coefficient (ICC), or α_K ,where the subscript the shell of the ejected electron.





$$\alpha_K = \frac{1}{\omega_K}\frac{N_K}{N_\gamma}\frac{\varepsilon_\gamma}{\varepsilon_K}$$

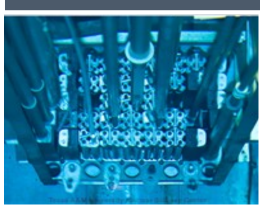
ω_k=fluorescence yield, N_k = x –ray peak area, N_γ=γ ray peak area
ε_γ= γ ray detector efficiency, ε_k=x-ray detector efficiency

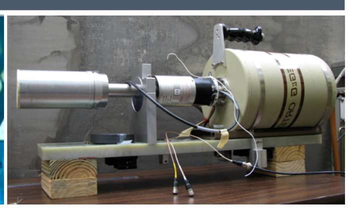
L to R, T to B: γ vs. e- emission, β- Feynman diagram, K shell ICC formula, Variable definitions

MOTIVATION

- Measure ICCs to high precision and investigate the accuracy of theoretical calculations that include or exclude the atomic vacancy.
- Gain a better understanding of the α_K value used in basic science and applications to help balance decay-scheme intensities, assist in assigning multipolarities and spins, etc.

SETUP

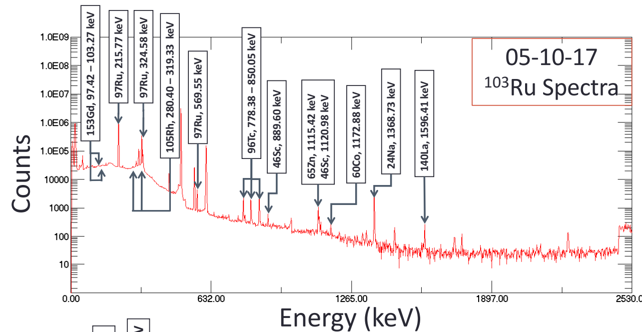


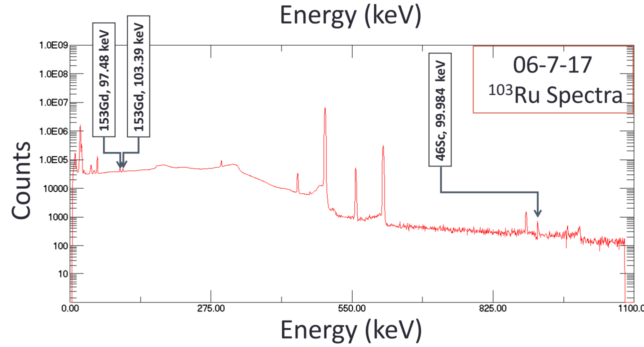


- We prepared a sample of ruthenium oxide by electrochemically depositing it on an aluminum backing and activating it with thermal neutrons at the Texas A&M TRIGA reactor (left) for 20 hours.
- Decay spectra were then recorded for roughly 120 hours with our HPGe detector (right), which has been precisely efficiency calibrated (±.15% relative precision).

IMPURITY ANALYSIS

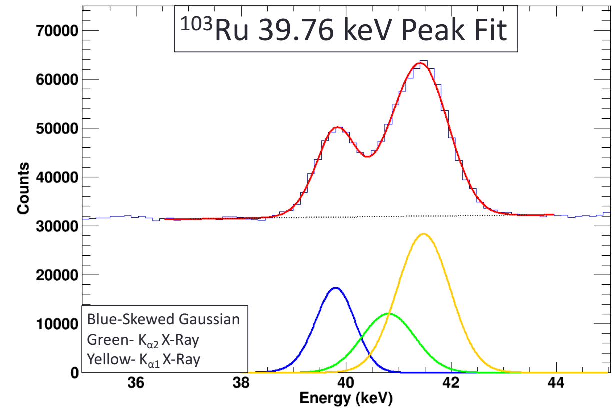
- Five series of decay and background spectra were taken over the course of roughly a month.
- Using the Maestro software package, we summed the decay series and corrected them using the background sums.
- Based on NNDC databases, impurities were identified and corrected for in the ICC calculation.





- All but two impurities died out between the acquisition of the first and last spectrum.
- The K_α x-rays group from a ^{153}Gd impurity overlapped the 39.76-keV ^{103}Rh gamma ray, preventing the area of the peak, necessary for the ICC calculation, to be extracted using Maestro.
- Three impurities made a noticeable contribution to the x-rays in the spectrum: ^{103}Ru-12.68(13)%, ^{97}Ru-0.098(9)%, and ^{97m}Te-0.0778(8)%.

AREA EXTRACTION



- The ROOT framework developed by CERN was used to fit the structure containing the ^{103}Rh gamma ray and ^{153}Gd *K* x-rays.
- The master fit was comprised of a first order polynomial for the background, a skewed Gaussian for the gamma ray, and two Voigt functions for the $K_{\alpha 1}$ and $K_{\alpha 2}$ x-rays.
- The best fit parameters were found, with the normalized chi-squared value equal to 4.1; the master fit was decomposed and the skewed Gaussian function integrated.
- The area of the 39.76-keV γ peak, combined with the contaminant-corrected Rh *K* x-ray area yielded a preliminary α_k value of 134.6(19).

RESULTS AND CONCLUSIONS

Vacancy	No Vacancy	Experimental
135.2	127.4	134.6(19)

Our preliminary experimental value for the ICC of ^{103}Rh demonstrates that *the atomic vacancy created in the internal conversion process must be considered in theoretical calculations*. This agrees with our measurements of other ICCs.

ACKNOWLEDGEMENTS

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